Space Weather Technical Forecast

Issued on Friday, 12 May 2023 at 01:27 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: G1-G2 Minor/Moderate geomagnetic storm conditions expected on 12 and 13 May, with a chance of G3/Strong storms due to an expected CME arrival. S1/Minor Solar Radiation Storm easing. R1/R2 Minor/Moderate radio blackouts expected.

Analysis of Space Weather Activity over past 24 hours
Solar Activity: Solar activity has been Moderate over the last 24 hours, with two M-class flares, peaking with an M2.1 flare from AR3294 at 11/0901UTC. AR3294 then produced a second M1.9 flare at 11/1829UTC. Both these produced potentially Earth directed CMEs. The first is forecast to perhaps glance the Earth on 14 May, but with low confidence. The second CME will be analysed once sufficient imagery becomes available. AR3294 is one of nine sunspot regions on the visible disc. AR3293, after fading to plage has redeveloped as a weak unipolar region. AR3296 is weakening and becoming less complex. AR3297 appears to contain some limited complexity. The remaining five of nine numbered regions all appear to be stable or benign. Aside from the CME mentioned, no further Earth-directed CMEs have been identified on available imagery.

Solar Wind / Geomagnetic Activity: The solar wind speed at L1, was following a declining trend for much of the period, but then started a slight upward turn to reach 500km/s by 11/2200UTC. Density was around average, again with a brief increase at the end of the period, to reach 11ppcc by 11/2200UTC. Total magnetic field strength was weak but reached 7nT at 11/2218UTC, but the north-south component varied weakly throughout. These slight increases in parameters may be indicative of a weak CME shock, but observations will continue as a larger shock is forecast. Phi angle was mainly positive (away from the Sun). Geomagnetic activity has been Quiet to Unsettled.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV), as measured at GOES16, declined below the S1 threshold over the past 24 hours, with a peak of 22pfu at 11/0000UTC on a declining trend, falling below threshold at 11/0400UTC. High energy electron flux (greater than 2MeV), as measured at GOES16, has varied between background and moderate levels on a diurnal trend. The 24-hour integrated fluence has been well below Active levels, but with a slightly increasing trend. At 12/0000UTC 1.52e7 integrated pfu was recorded.

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Met Office Space Weather Technical Forecast

Four-Day Space Weather Forecast Summary
Solar Activity: Moderate to High solar activity is forecast to continue through the next four days, due to a combination of activity from AR3296, AR3297 and AR3294. There is a likelihood of M-class flares and a chance of X-class flares.

Solar Wind / Geomagnetic Activity: A full halo CME which left the Sun on 09 May was due to arrive at Earth on 11 May, and although a limited shock has been observed, a more significant shock is still forecast. The effects on the speed, density and magnetic strength from the CME could continue into 13 and 14 May, and could mask a possible coronal hole high speed stream connection on 13 May. Geomagnetic activity is forecast to start Quiet, becoming Unsettled to Active due to the onset of the forecast CME, with G1 or G2 (Minor or Moderate) Storms expected. There is also a chance of G3 (Strong) storms, especially during the initial shock of the CME. Continued storm intervals, with a declining strength are then possible through 13 May, with any further G1 or G2 storm intervals on 14 and 15 May dependent on the magnitude of the initial shock.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux gradually declining to background levels unless any further significant flares occur, particularly from AR3296 as it nears the western limb in the coming days, or from the increasing activity from AR3294. Protons may also see enhancement due to the onset of the 09 May CME, which is now forecast to arrive on 12 May. High energy (greater than 2MeV) electron flux is expected to persist at normal background to moderate levels. The associated 24-hour fluence is forecast to persist below the Active threshold.

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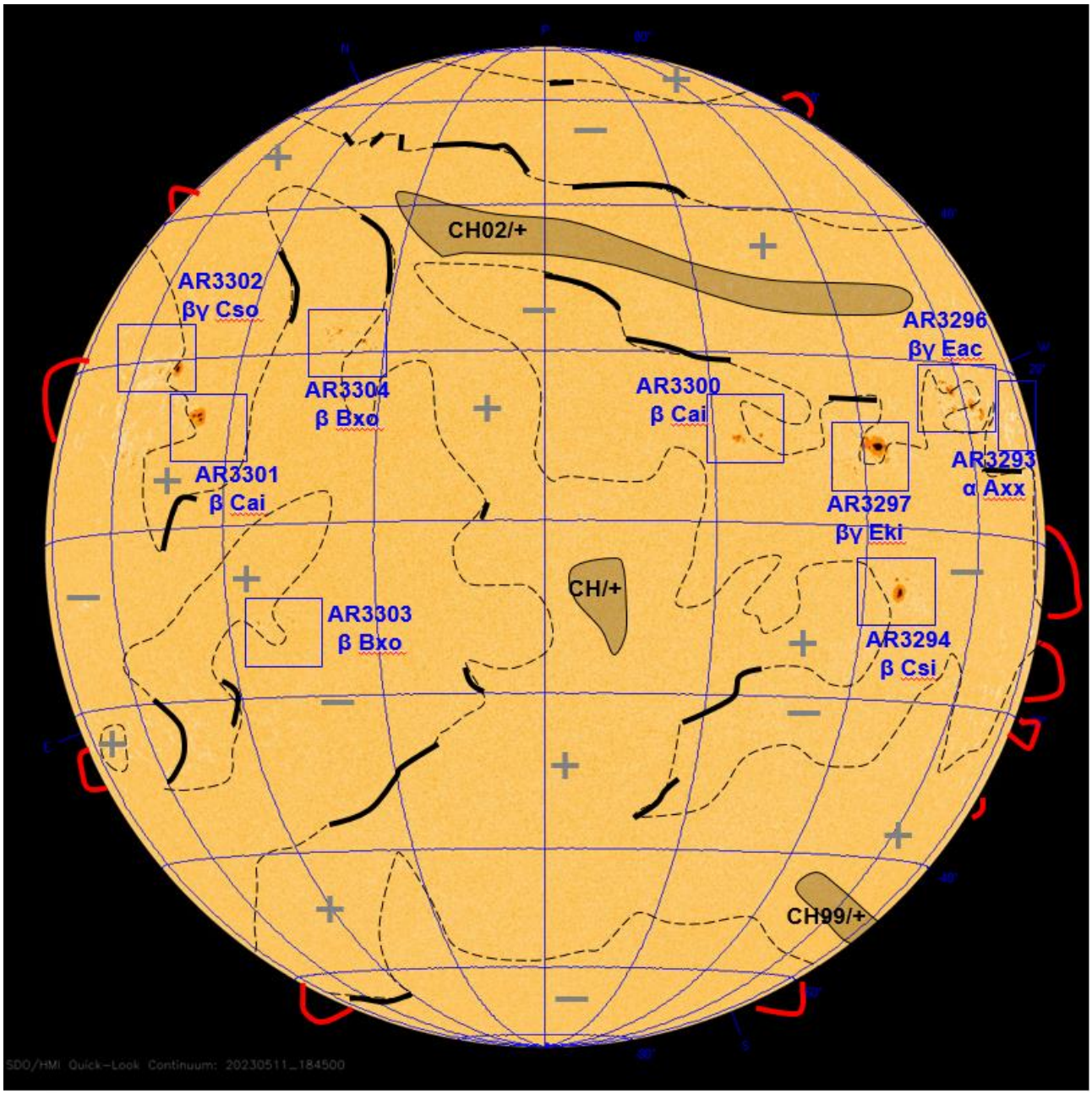
Figure 1. Solar Analysis Valid 11/2000UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A full halo CME which left the Sun late on 09 May, was due to arrive late on 11 May, and is now due to arrive early on 12 May. Assuming an arrival early on 12 May, any effects are then likely to continue through the day and into 13 May. Analysis of a further apparent partial CME which left the region of AR3294 during 11 May is currently being inhibited by a lack of satellite data but will be analysed once sufficient data becomes available.

Otherwise a weak coronal hole may affect Earth on 14 May, although the onset of this is subject to be being masked by residual CME effects.

Geomagnetic activity is forecast to start Quiet, but soon increasing to generally Unsettled to Active levels due to the onset of the 09 May CME. The CME arrival could give an expected risk of G1 or G2 (Minor or Moderate) storms with a likelihood of G3 (Strong) storm intervals. Following the CME arrival these effects could continue through 13 May. There is then a decreasing risk of geomagnetic storm intervals through 14 and 15 May as the influence of the CME is forecast to subside.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	90	80	20	10
Strong	G3	No	50	30	5	1
Severe	G4	No	15	10	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
09/1200	Full	AR3296	NW	1450km/s	11/01800	Shock expected but currently overdue.

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Figure 2: Visualisation of solar wind parameters at L1. A slight shock is discernible at the end of the period, but this is significantly lower than expected and may represent a weaker CME ahead of the main forecast CME.

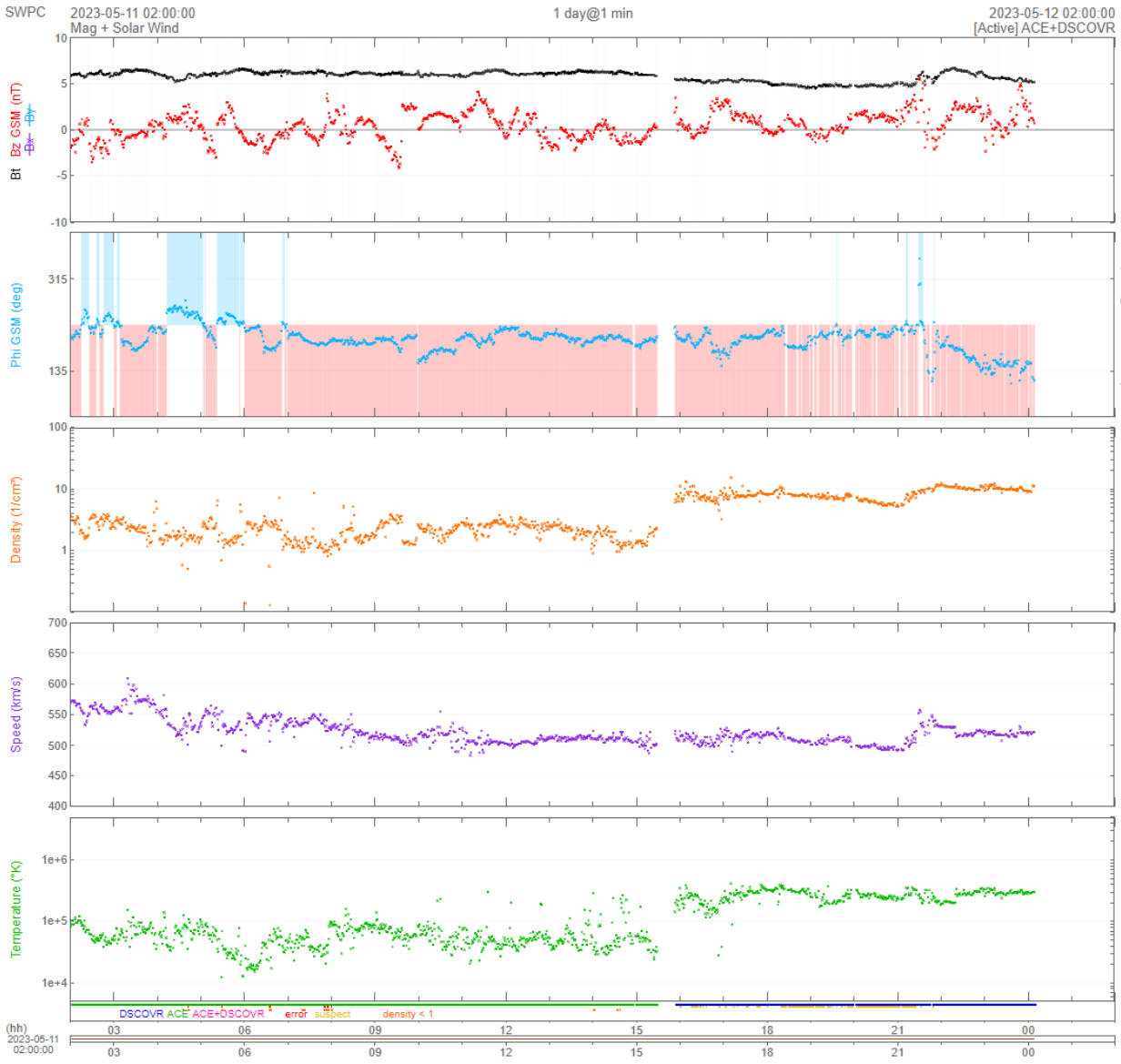

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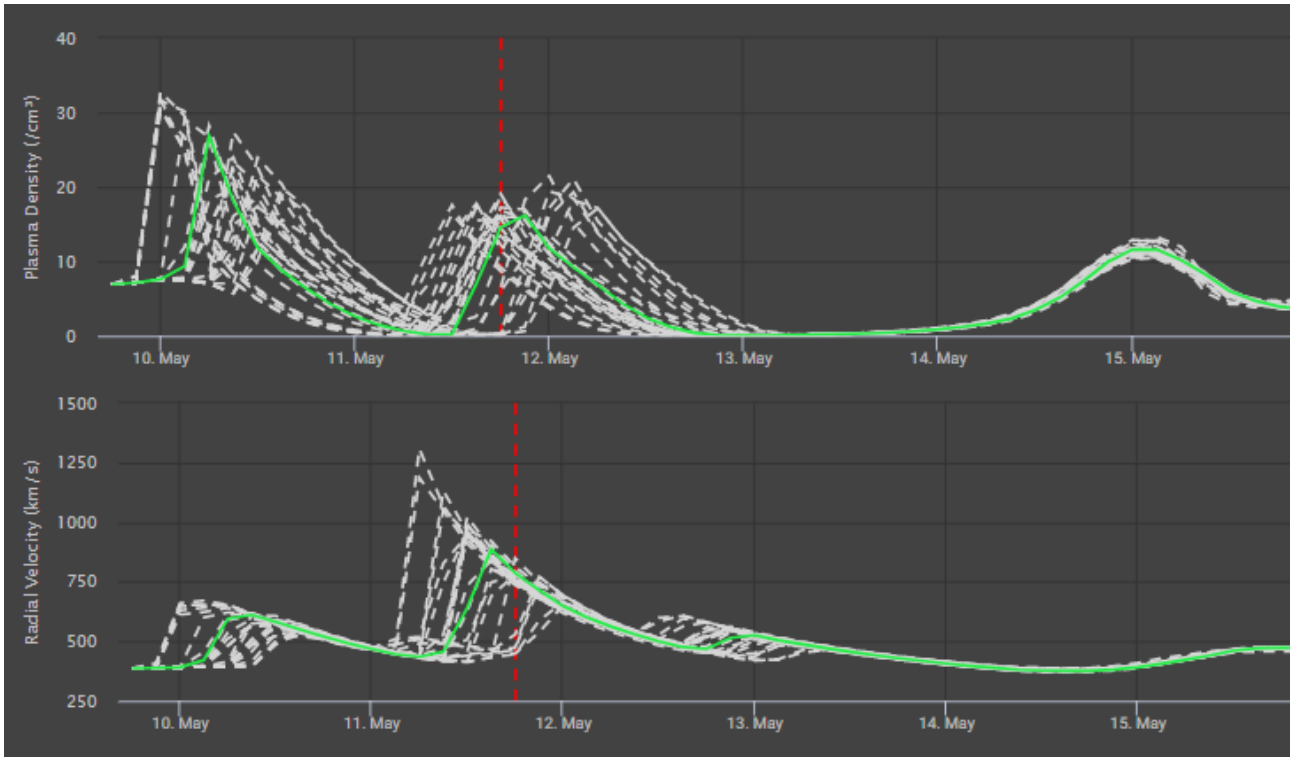
Figure 3: MOSWOC Enlil ensemble model, showing the spread of possible arrival times on 11 and 12 May.



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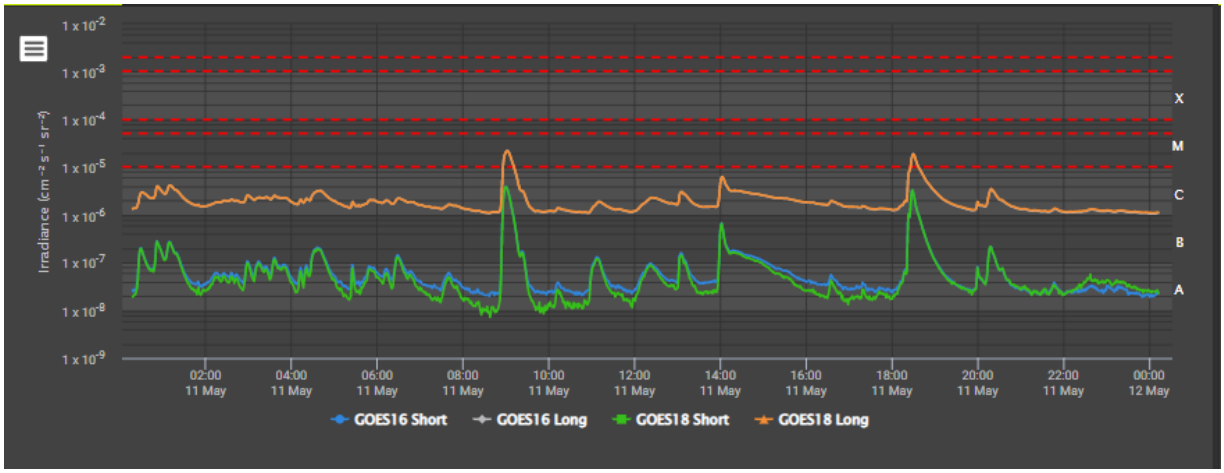
Radio Blackouts - X-Ray Flares:
There are 11 sunspot regions on the visible disc. The most active of these is AR3294, a mature region in the southwest quadrant, which has developed and produced two low energy M-class flares within the last 24 hours. AR3293 appears to be fading rapidly, with some simplification also observed in AR3296, although this region is becoming difficult to analyse as it approaches the northwestern limb. AR3297 also appears to be showing some signs of development. The remaining regions appear to be simple or are simplifying.

Solar activity is expected to be mainly Moderate through the next four days, but with a decreasing risk as some complex regions fade and rotate across the western limb. There is also a decreasing chance of high activity and Strong flares through the next four days.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	60	60	60	50
Very Active	R3 to R5 X Class	No	20	15	15	10

Figure 4: GOES 16 X-ray flux. The two M-class flares both originated from AR3294.



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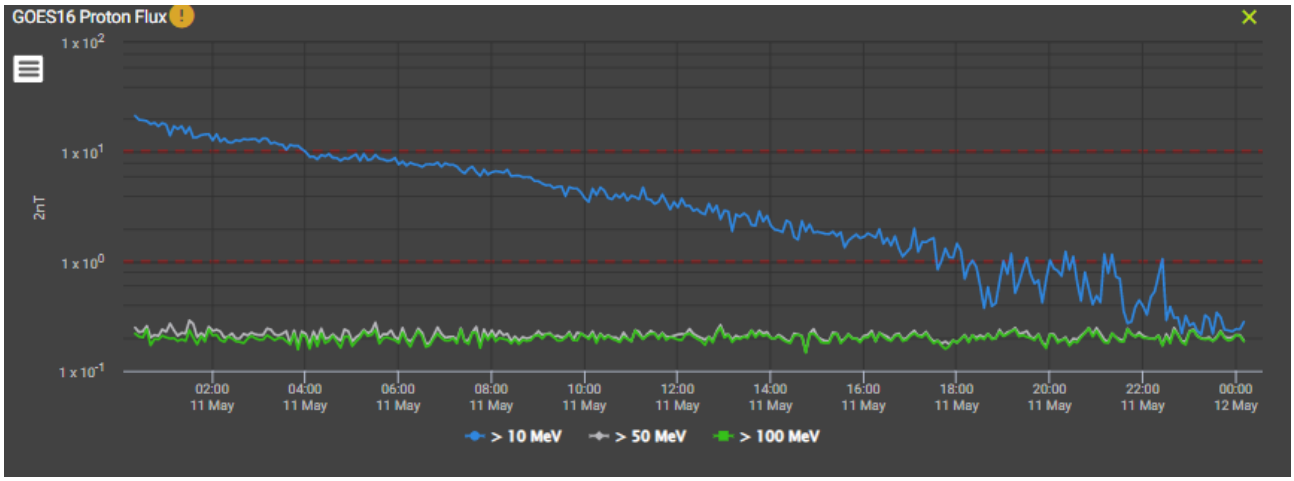
Solar Radiation Storms - (High Energy Protons):
The high energy (greater than 10MeV) proton flux, as observed by GOES16 is now below the S1/Minor Storm threshold. There remains a likelihood of increasing above the threshold, especially on 12 May due to the forecast arrival of a full halo CME, although this is low confidence. An increase in activity from AR3294, along with the existing complexity of AR3296 could result in increased proton counts during any energetic flares from these regions, as they are now both in the western hemisphere.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	50	30	20	20
Very Active	**≥ S3 ***	No	5	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 5: GOES 16 proton flux



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High Energy Electrons Event (≥ 2MeV):
The high energy electron flux (greater than 2MeV) is expected to remain below the high level through much of the period, due to a combination of significant geomagnetic activity redistributing elections away from GEO orbits and also increased solar wind speeds distorting the electron belts away from GEO. The British Antarctic Survey Radiation belt Model (BAS-RBM) is suggesting that the anticipated CME could feed electrons into lower Earth orbits, where they could be contained until any CME effects and solar wind speeds ease later in the period. This would allow the belts to relax back towards their natural orbits.

Electron fluence values are on a slight increasing trend due to the recent CME effects and fast solar wind, but appear to have reached a plateau. Values are expected to remain below the Active (1e8 integrated pfu) level throughout, but with decreasing confidence towards the end of the period, as the effects of forecast CME arrivals and solar wind speeds subside.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^{8}$	No	10	10	20	30
Very Active	≥ 2 MeV ≥ $1x10^{9}$	No	1	1	1	5

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